In the Specification

Kindly replace paragraphs [0001] through [0002] with the following:

Technical Field~~ of the Invention~~

~~The present invention~~This disclosure relates to RTM (Resin transfer Molding) molding method and device for molding a relatively large FRP (Fiber Reinforced Plastic), and more specifically, to RTM molding method and device capable of achieving a high-speed molding and improving a surface quality.

Background~~ Art of the Invention~~

FRP, in particular, CFRP (carbon fiber reinforced plastic), is utilized in various fields as a composite material having a property light in weight and high mechanical properties. As one of FRP molding methods, an RTM molding method is known wherein a reinforcing fiber substrate such as a laminated substrate of reinforcing fiber woven fabrics is placed in a mold, and after the mold is clamped, a liquid resin is injected into the mold reduced in pressure, and the resin is heated and cured. Further, in such a conventional molding, it is proposed to give a certain shape to a reinforcing fiber substrate before disposing it in a mold by clamping it with upper and lower preforming dies (for example, ~~Patent document 1~~JP-A-2003-305719).

Kindly replace paragraph [0005] with the following:

As a method of impregnation even for a product to be molded which is complicated to some extent and large, there is a method described in ~~Patent document 2, etc~~JP-A-2002-234078. In this method, a carrier of a matrix resin, for example, prepared by impregnating a molten resin into a sponge material, is used instead of the resin film in the aforementioned RFI method, and although it is an improved method, because a method for covering the entire product to be molded with a bagging film and reducing in pressure the inside thereof is employed as a method for

achieving pressure impregnation for a large product in an inexpensive and easy manner, a pressurizing force of only 0.1 MPa can be generated at maximum, and therefore, there are problems that impregnation for a thick product is difficult and that impregnation up to detailed portions is difficult.

Kindly replace paragraph [0007] with the following:

Further, as a conventional RTM molding method, a method is also known wherein resin is injected at a pressurized condition from a single injection line. For example, when a product to be molded has a shape of a polygon (a shape with a plurality of sides), the resin is injected from a certain one side toward another side opposite to the certain one side (for example, ~~Patent document 3, Patent document 4~~JP-A-8-58008 and JP-A-2003-11136). In such a method, however, although the resin surely flows from one side toward the opposite side while the resin is impregnated into a reinforcing fiber substrate in order, if the product to be molded is relatively large, it takes much time to flow the resin, and as the case may be, the resin may reach a time of its gelation during its flow, in such a condition there is a problem that the resin flow stops before complete impregnation. Accordingly, as described in the aforementioned ~~Patent document 3~~JP-A-8-58008, a method for providing resin injection lines at a plurality of positions of a product to be molded and injecting the resin in order is proposed. In this method, however, since the resin is injected from portions within a molding area of the product to be molded, it cannot be applied to a sandwich molded product using a core material and disposing reinforcing fiber substrates on both surfaces of the core material, because the resin cannot be injected from a mold surface side. Further, even in a case of a non-sandwich molded product, the method cannot be applied to the molding of a product which is double-sided and which requires a high design quality for its surface. Thus, in the above-described conventional RTM molding methods, it is difficult to efficiently mold a relatively large product.

Kindly replace paragraphs [0009] through [0010] with the following:

In particular, in a case where resin injection is carried out at a high resin discharge pressure of 0.5 MPa or more (therefore, at a high flow rate) ~~in order~~ to shorten a molding time or ~~in order~~ to mold a product having a large area in a short period of time, disturbance of the weave structure of a reinforcing fiber substrate (particularly, a plain weave fabric) is liable to occur, and further, because the resin flows in the mold at a high speed, the resistance against the flow disperses within the flow area depending upon a dimensional unevenness (particularly, an unevenness in thickness) of a cavity in the mold, a fine unevenness in thickness of the substrate, or a difference between partial structures of the substrate due to overlapping of substrate layers and the like, and because a uniform flow cannot be maintained, there is a case where a large void is generated by occurrence of a local forestalling of the resin flow and the like. Furthermore, there is a case where the resin actually flows up to the substrate portion, but, because the flow rate is high, for example, there is no time for release of gas present in the texture of the woven fabric and the gas stays there, and the gas generates a surface defect such as a pinhole. In such conventional molding conditions and molding process causing reduction of quality in appearance concerning the design quality such as substrate disturbance, voids and pinholes, it is difficult to ensure a high surface quality while carrying out a high-speed injection for shortening the molding time. The larger the size of a product to be molded becomes, the more frequently such defects on quality in appearance are liable to occur, because a high-speed resin injection is to be inevitably employed.

Because the flow state of resin greatly influences generation of such voids and pinholes concerning design quality, the density of the reinforcing fiber substrate, that is, the weight thereof, also becomes an important factor. Namely, because a weight of reinforcing fibers per one layer in-fluences a flow resistance of resin and easiness of gas release, it is necessary to set a proper weight

in accordance with the resin flow condition. This proper weight has to be set from the viewpoints of not only the surface quality but also the workability and utilization factor in strength of a preform. Namely, if the weight is too great and the rigidity of the substrate becomes high, the reinforcing fiber substrate becomes hard to be situated along the mold surface and hard to be formed in a three-dimensional shape, and there is a case where it takes much working time to make a preform, or that at that time disturbance of the substrate occurs and the mechanical properties of the FRP molded product decrease. Namely, ~~in order~~ to carry out an efficient production, there is a proper weight corresponding to the production conditions (molding size·shape, molding conditions, etc.).

Kindly replace paragraph [0016] with the following:

Further, ~~in order~~ to improve the surface quality of a molded product as one of the purposes, a method is proposed wherein a reinforcing fiber substrate is given with a certain shape before it is disposed in a mold, by nipping it with upper and lower dies for preforming prior to RTM molding, and only the reinforcing fiber substrate preformed is disposed directly on the molding surface (for example, the aforementioned ~~Patent document 1~~JP-A-2003-305719).

Kindly replace paragraph [0018] with the following:

As the countermeasure for preventing occurrence of such voids and pinholes injuring the design quality of the design surface, there is a case where a random mat layer is provided on the upper surface of a surface-layer substrate. This random mat layer is called as "a surface mat" because the random mat layer becomes an outermost layer, and particularly in a prepreg/autoclave curing method, an RFI (Resin Film Infusion) method, a hand-lay-up method, etc., it is sometimes employed. However, the structure thereof is a substrate structure in which the surface substrate and the random mat layer are completely replaced with each other, as compared the embodiment ~~of~~

~~the present invention~~ described later.

Kindly replace paragraphs [0020] through [0028] with the following:

In a case where an FRP is molded by an RTM molding method or a vacuum molding method by using the above-described random mat as a surface mat and disposing it as an outermost layer, the random mat in a state of a dry substrate is pressed to the mold surface, and a gap between the mold surface and the random mat is very small because the bulkiness of the random mat with a low weight is low. Therefore, the resin flowability into the gap is poor, and as a result, voids and pinholes are liable to occur at the position thereof. Thus, particularly in an RTM molding method and a vacuum molding method, even if a random mat layer is provided as an outermost layer (a surface layer at a design surface), occurrence of voids and pinholes cannot be prevented.

~~Patent document 1: JP-A-2003-305719~~

~~Patent document 2: JP-A-2002-234078~~

~~Patent document 3: JP-A-8-58008~~

~~Patent document 4: JP-A-2003-11136~~

~~Disclosure of the Invention~~

~~Problems to be solved by the Invention~~

Accordingly, paying attention to the above-described ~~present~~ situations, ~~a first object of the present invention is~~ <u>it could be helpful</u> to provide <u>an</u> RTM molding method and device wherein, even as for a relatively large three-dimensional configuration, the molding process from resin injection to impregnation and curing can be carried out at a high speed as compared with conventional RTM molding method and device, without generating non-resin-flowing areas, thereby achieving shortening of the molding time, increase of production speed and production amount, in

particular, increase of production amount per one mold, and reducing the production cost.

Further, ~~a second object of the present invention is~~it could be helpful to provide an RTM molding method and device wherein, in an RTM molding for molding a relatively large fiber reinforced plastic product with a projection area of substantially 1 m^2 or more, a voidless high-quality product can be molded efficiently in a short period of time.

Furthermore, ~~a third object of the present invention is~~it could be helpful to provide an RTM molding method wherein injected resin can be surely and easily delivered over the entire range of a desirable area in the resin injection step, and a fiber reinforced plastic with an improved surface quality can be produced by preventing occurrence of voids and pinholes on a surface, in particular, on the design surface side.

~~Means for solving the Problems~~Summary

~~To achieve the above-described objects,~~We provide an RTM molding method ~~according to the present invention comprises~~comprising the steps of disposing a reinforcing fiber substrate in a cavity of a mold consisting of a plurality of dies, clamping the mold, and thereafter injecting resin to complete molding, and [[is]]characterized in that divided areas with respect to a surface direction of the reinforcing fiber substrate are assumed, each divided area is one in which injected resin expands over the entire surface in each divided area and can be substantially uniformly impregnated in a thickness direction of the substrate, and resin introducing paths are formed for respective assumed divided areas for introducing the injected resin into the respective divided areas. In this RTM molding method, vacuum suction may be carried out from a resin discharge line for a predetermined period of time of at least from a time after clamping the mold to a time starting resin injection.

Further, we provide an RTM molding device ~~according to the present invention~~ for disposing a reinforcing fiber substrate in a cavity of a mold consisting of a plurality of dies, clamping the mold, and thereafter injecting resin to complete molding, is characterized in that divided areas with respect to a surface direction of the reinforcing fiber substrate are assumed, each divided area is one in which injected resin expands over the entire surface in each divided area and can be substantially uniformly impregnated in a thickness direction of the substrate, and resin introducing paths are formed for respective assumed divided areas for introducing the injected resin into the respective divided areas. In this RTM molding device, the device may have means for carrying out vacuum suction from a resin discharge line for a predetermined period of time of at least from a time after clamping the mold to a time starting resin injection.

In the above-described RTM molding method and device ~~according to the present invention~~, for a reinforcing fiber substrate with a relatively large area, adequate divided areas are assumed, resin introducing paths are formed for respective assumed divided areas for introducing the injected resin into the respective divided areas, and by injecting the resin via the resin introducing paths, as the result, the resin is impregnated quickly and uniformly over the entire range of the reinforcing fiber substrate. The number of division of the divided areas may be a countable number as shown in the first and second embodiments described later, or may be substantially innumerable number as shown in the third embodiment described later.

Then, ~~in order to achieve the above described first object, the present invention~~ we provide[[s]] an RTM molding method wherein an intermediate member having resin paths extending through the intermediate member in its thickness direction is disposed between dies forming the mold, and resin is injected to the reinforcing fiber substrate from a plurality of positions via the intermediate member almost simultaneously (method according to a first embodiment).

Further, ~~the present invention~~we provide[[s]] an RTM molding device wherein an intermediate member having resin paths extending through the intermediate member in its thickness direction is disposed between dies forming the mold for injecting resin to the reinforcing fiber substrate from a plurality of positions via the resin paths almost simultaneously (device according to a first embodiment).

Kindly replace paragraph [0034] with the following:

Further, ~~in order~~ to improve the sealability at a position of parting surfaces of dies of the mold, particularly, ~~in order~~ to improve the sealability at a resin injection or discharge portion to shorten the cycle time of the RTM molding, a structure can be employed wherein a tube for resin injection and/or a tube for resin discharge is provided being nipped between parting surfaces of dies, and portions between the tube and the dies are sealed with an elastic material (an elastic material for seal).

Kindly replace paragraph [0036] with the following:

Further, ~~in order~~ to discharge bubbles due to evaporation of gas dissolved in the resin which is generated during resin injection or residual fine bubbles in corner portions of the mold, a structure can be employed wherein, while the resin is injected into the mold at a pressurized condition, gas and excessive resin in the mold are discharged intermittently.

Kindly replace paragraphs [0041] through [0042] with the following:

The above-described RTM molding method and device according to the first embodiment ~~achieve the aforementioned objects based on~~employ the following basic concept. Namely, any way, the number of the resin injection ports is increased, and a resin flowing region per one injection port is made small. Then, before the resin is impregnated into the reinforcing fiber substrate, the resin is once flown on the surface of the substrate and stored there, and a pressure is

applied to the resin and the resin is flown and impregnated at a time over the entire area. At that time, the substantial resin flow is controlled at a range corresponding to the thickness of the substrate. Namely, the resin is flown in a surface direction over a sufficiently wide area beforehand, and from there, the resin is flown and impregnated at a time in the thickness direction of the substrate. Therefore, the resin is injected into the substrate from the entire area (not from the circumference), and the resin is impregnated into the substrate very quickly. The resin discharge is preferably carried out from the circumference (as the case may be, from the entire circumference).

~~In order to~~To carry out such a resin flow operation, in the above-described RTM molding method and device, an intermediate member forming resin paths (for example, an intermediate plate for resin injection multi-port) is disposed between dies, for example, between one-side die (for example, an upper die) and the other-side die (for example, a lower die), and the resin is injected to the reinforcing fiber substrate from a plurality of positions via the intermediate member almost simultaneously. For example, the resin is flown to the reinforcing fiber substrate almost simultaneously from a plurality of injection ports provided on the intermediate member, and the resin is flown almost uniformly over the entire area of the substrate.

Kindly replace paragraphs [0044] through [0045] with the following:

Further, ~~in order to achieve the above-described second object, the present invention~~we provide[[s]] an RTM molding method wherein, after resin is impregnated into the reinforcing fiber substrate by injecting the resin from a resin injection line toward a resin discharge line, which are disposed on an outer circumference of the cavity, the resin is heated and cured, and the resin injection line is divided into a plurality of parts (method according to a second embodiment).

Further, ~~the present invention~~we provide[[s]] an RTM molding device wherein, after resin is impregnated into the reinforcing fiber substrate by injecting the resin from a resin injection line toward a resin discharge line, which are disposed on an outer circumference of the cavity, the resin is heated and cured, and the resin injection line is divided into a plurality of parts (device according to a second embodiment).

Kindly replace paragraph [0051] with the following:

Further, ~~in order~~ to improve the sealability at a position of parting surfaces of dies of the mold, particularly, ~~in order~~ to improve the sealability at a resin injection or discharge portion to shorten the cycle time of the RTM molding, a structure can be employed wherein a tube for resin injection and/or a tube for resin discharge is provided being nipped between parting surfaces of dies, and portions between the tube and the dies are sealed with an elastic material (an elastic material for seal).

Kindly replace paragraph [0053] with the following:

Further, ~~in order~~ to discharge bubbles due to evaporation of gas dissolved in the resin which is generated during resin injection or residual fine bubbles in corner portions of the mold, a structure can be employed wherein, while the resin is injected into the mold at a pressurized condition, gas and excessive resin in the mold are discharged intermittently.

Kindly replace paragraph [0058] with the following:

Further, ~~in order~~ to achieve the aforementioned third object, ~~the present invention~~we provide[[s]] an RTM molding method wherein at least one surface layer of the reinforcing fiber substrate comprises a continuous fiber layer, and a layer positioned immediately under the surface layer comprises a random mat layer (method according to a third embodiment).

Kindly replace paragraphs [0066] through [0067] with the following:

~~Effect according to the Invention~~

In the RTM molding method and device ~~according to the present invention~~, since adequate divided areas are assumed and the injected resin can be delivered enough to the respective divided areas and can be impregnated well into the respective divided areas even if a reinforcing fiber substrate with a relatively large area is used, the molding process from resin injection to impregnation and curing can be carried out at a high speed without generating non-resin-flowing areas, thereby achieving shortening of the molding time and increase of production speed and production amount, and reducing the production cost. Further, the resin can be impregnated at a desirable state over the entire are a, thereby improving the surface quality of the molded product.

In particular, in the RTM molding method and device according to the first embodiment, since the resin is flown in advance so as to be spread to a sufficiently wide area via the intermediate member and thereafter the resin is injected into the reinforcing fiber substrate from a plurality of positions almost simultaneously and uniformly, even as for a relatively large three-dimensional configuration, the molding can be carried out at a high speed without generating non-resin-flowing areas. As a result, the molding time is greatly shortened, it becomes possible to increase the production speed and the production amount, and it becomes possible to reduce the production cost by increasing the production amount per one mold. Further, [[E]]even as for a large-sized product to be molded, it becomes possible to easily prevent generation of resin non-impregnated portions, thereby improving the quality of the molded product.

Kindly replace paragraph [0070] with the following:

Brief ~~explanation~~Description of the [[d]]Drawings

~~[Fig. 1]~~ Fig. 1 is an exploded perspective view of a device used in an RTM molding method according to a first embodiment~~of the present invention~~.

~~[Fig. 2]~~ Fig. 2A is a plan view of an upper die of the device depicted in Fig. 1, and Fig. 2B is an elevational view thereof.

~~[Fig. 3]~~ Fig. 3A is a plan view of an intermediate member of the device depicted in Fig. 1, and Fig. 3B is a sectional view as viewed along the line C-C of Fig. 3A.

~~[Fig. 4]~~ Fig. 4A is a plan view of a lower die of the device depicted in Fig. 1, and Fig. 4B is a sectional view as viewed along the line C-C of Fig. 4A.

~~[Fig. 5]~~ Fig. 5 is a sectional view of a device used in an RTM molding method according to another embodiment different from the first embodiment~~of the present invention~~.

~~[Fig. 6]~~ Fig. 6 is a bottom view of an upper die of the device depicted in Fig. 5.

~~[Fig. 7]~~ Fig. 7 is a plan view of a lower die of the device depicted in Fig. 5.

~~[Fig. 8]~~ Fig. 8 is a perspective view of a mold used in RTM molding method and device according to a second embodiment~~of the present invention~~.

~~[Fig. 9]~~ Fig. 9 is a plan view of a lower die of the mold depicted in Fig. 8.

~~[Fig. 10]~~ Fig. 10 is a vertical sectional view of the lower die depicted in Fig. 9.

~~[Fig. 11]~~ Fig. 11 is a schematic diagram of the whole of an RTM molding system using the RTM molding method and device according to the second embodiment~~of the present invention~~.

~~[Fig. 12]~~ Fig. 12 shows graphs of characteristics of a resin used in our examples~~of the present invention~~.

~~[Fig. 13]~~ Fig. 13 is a partial sectional view showing a structure of a preform substrate of fiber reinforced resin molded by an RTM molding method according to a third embodiment~~of the present invention~~.

~~[Fig. 14]~~ Fig. 14 is a partial sectional view showing an aspect at the time of injecting and impregnating resin into the substrate depicted in Fig. 13.

~~[Fig. 15]~~ Fig. 15 is a partial sectional view showing a structure of a preform substrate of fiber reinforced resin molded by an RTM molding method according to another embodiment different from the third embodiment~~ of the present invention~~.

~~[Fig. 16]~~ Fig. 16 is a partial sectional view showing an aspect at the time of injecting and impregnating resin into the substrate depicted in Fig. 15.

~~[Fig. 17]~~ Fig. 17A is a partial sectional view of the surface layer substrate of the preform substrate depicted in Fig. 13, and Fig. 17B is a plan view thereof.

~~[Fig. 18]~~ Figs. 18A to 18C are schematic diagrams showing a molding method capable of being used in the third embodiment~~ of the present invention~~.

~~[Fig. 19]~~ Fig. 19 is a partial sectional view showing a structure of a fiber reinforced resin according to another embodiment different from the embodiment depicted in Fig. 13.

~~[Fig. 20]~~ Fig. 20 is a schematic exploded perspective view of a mold showing an example of a structure for improving sealability in RTM molding method and device according~~ to the present invention~~.

~~[Fig. 21]~~ Fig. 21 is a vertical sectional view of a mold showing another example of a structure for improving sealability.

~~[Fig. 22]~~ Fig. 22 is a perspective view of a tube portion for resin injection ~~dsicharge~~discharge used for parting surfaces of dies of a mold.

~~[Fig. 23]~~ Figs. 23A to 23F are schematic diagrams showing various examples of sealing forms for tube portions for resin injection ~~dsicharge~~discharge disposed on parting surfaces of dies of molds.

Kindly replace paragraphs [0072] through [0073] with the following:

~~The Best mode for carrying out the Invention~~<u>Detailed Description</u>

Hereinafter, desirable embodiments ~~of the present invention~~ will be explained referring to figures.

First, as the reinforcing fibers ~~in the present invention~~, carbon fibers, glass fibers, aramide fibers, metal fibers, boron fibers, alumina fibers, silicon carbide high-strength synthetic fibers, etc. can be used, and particularly carbon fibers are preferable. The form of the reinforcing fiber substrate is not particularly limited, a unidirectional sheet or a woven fabric can be employed, usually a plurality of these are stacked to form a reinforcing fiber substrate, and it is used as a formation of a preform given with a predetermined form beforehand in accordance with requirements.

As the resin used in the RTM molding method and device ~~according to the present invention~~, a thermosetting resin, which is low in viscosity and easy to be impregnated into reinforcing fibers, or a monomer for RIM (Resin Injection Molding) forming a thermoplastic resin, etc., is suitable. As the thermosetting resin, for example, an epoxy resin, an unsaturated polyester resin, a polyvinylester resin, a phenolic resin, a guanamine resin, a polyimide resin such as bismaleimide triazine resin, a furan resin, a polyurethane resin, a polydiarylphthalate resin, further, a melamine resin, a urea resin, an amino resin, etc. can be raised.

Kindly replace paragraphs [0078] through [0079] with the following:

Further, ~~the present invention~~<u>this disclosure</u> can be applied to molding of a fiber reinforced resin structural material having a lamination structure of a fiber reinforced resin and a core material. For example, a sandwich structure in which fiber reinforced resin layers are disposed on both sides of a core material can be raised. It is possible to use an elastic material, a

foamed material or a honeycomb material as the core material, and a foamed material and a honeycomb material are preferable for lightening in weight. The kind of the foamed material is not particularly limited, and for example, a foamed material of a polymer such as polyurethane, acrylic, polystyrene, polyimide, vinyl chloride or phenol can be used. The material of the honeycomb material is not particularly limited, and for example, an aluminum alloy, a paper, an aramide paper, etc. can be used.

Figs. 1 to 4 show RTM molding method and device according to a first embodiment ~~of the present invention~~. In Fig. 1, a mold 1 comprises a plurality of dies, and in this embodiment, it has an upper die 2 made of a steel as a one-side die and a lower die 4 made of the same material as the other-side die and has an intermediate plate 3 made of a resin (for example, polyethylene) as an intermediate member. Resin injection paths and injection ports are formed by these upper die 2 and intermediate plate 3. Grooves 5 for resin injection path, which communicate with a resin injection member 8, are processed on intermediate plate 3, and a through hole 6 for injection port is processed at an end portion of each groove 6. The resin injection member 8 is formed from a metal pipe of a resin tube, and it is sealed relative to a metal die forming upper die 2 and intermediate plate 3 by a seal material 10a made of an elastic material such as a rubber. The circumference of upper die 2 and intermediate plate 3 is sealed by an O-ring 7, and the O-ring 7 is combined with seal material 10a. On four corners of upper die 2, guides 13 are provided for connecting the upper die 2 to intermediate plate 3 and lower die 4.

Kindly replace paragraphs [0089] through [0090] with the following:

Example 1

In the above-described respective embodiments, when molding was carried out setting the size of a mold at 1500 mm x 1200 mm x depth 3 mm at the molding surface (the cavity surface),

using a laminate of 8 plies of "TORAYCA" T700 cloth BT70-30 (300 g/m^2) produced by Toray Industries, Inc. as the reinforcing fiber substrate, and using a high-speed curing type epoxy resin (main ingredient: "Epicoat" 828 (an epoxy resin produced by Yuka Shell Epoxy Corporation), curing agent: blend TR-C35H (an imidazole derivative) produced by Toray Industries, Inc.) as the resin, in spite of a relatively large molded product, a good and quick molding could be carried out. ~~Where, the~~The time for completing the impregnation of the resin into the substrate was 5 minutes or less at a resin injection pressure of 0.7 MPa, and could be shortened down to 1/5-1/10 or less of a conventional method.

Figs. 8 to 12 show RTM molding method and device according to the second embodiment ~~of the present invention~~. Fig. 11 is a schematic diagram showing an example of a molding system 54 using an RTM molding device~~ according to the present invention~~. A mold 41 for RTM molding comprises an upper die 42 and a lower die 43, and the upper die 42 is attached to a mold lifting device 55 lifted by a hydraulic device for mold lifting 56 with a hydraulic pump 68 and a hydraulic cylinder 66. A reinforcing fiber substrate directly, or a preform substrate 44 (a reinforcing fiber substrate) given with a product shape beforehand so as to be easily placed in the mold, is disposed on the lower die 43, and then, the upper die 42 is closed. As the material of the mold, an FRP, a cast steel, a structural carbon steel, an aluminum alloy, a zinc alloy, a nickel electrocast material, and a copper electrocast material can be raised. For mass production, a structural carbon steel is preferred from the viewpoint of rigidity, thermal resistance and workability.

Kindly replace paragraph [0092] with the following:

~~Where, although~~Although the number and the positions of the resin injection tubes are different in accordance with the shape or the dimension of the mold or the number of molded products to be molded simultaneously in a single mold, in order to prevent the injection operation

from becoming troublesome by increase of the number of the positions for connecting the injection path 56, which extends from resin injection device 57, to resin injection tubes 46, 47, 48, the number of the injection tubes is preferably as few as possible. However, ~~in order~~ to mold a relatively large product at a high speed, it is possible to flow and impregnate the resin efficiently at a speed of several times relative to that in resin injection by a single injection tube, by using a plurality of resin injection tubes and carrying out the resin injection simultaneously or in order.

Kindly replace paragraph [0095] with the following:

In a case where a high-speed molding and a mass production are difficult by the conventional RTM molding method because the product to be molded is large as described above, as shown in Fig. 9, the problem can be solved by providing the resin injection line not at a single side of the outer sides of cavity 50 for molding but at a plurality of positions. Namely, by adding resin injection tubes 47, 48 toward resin discharge line 49 except the conventional resin injection tube 46 as the resin injection line, and injecting the resin simultaneously or in order from the resin injection line formed by resin injection runner 46c and resin injection film gate 46d, the resin injection line formed by resin injection runner 47c and resin injection film gate 47d and the resin injection line formed by resin injection runner 48c and resin injection film gate 48d, the problem of the resin flow damped at a condition of a high-order function can be solved. Namely, it is to provide the resin injection line and the resin discharge line so as to extend substantially over the entire area of the outer circumference of the product to be molded (that is, the whole of the reinforcing fiber substrate). A particularly effective method is to provide the resin injection line over the half or more of the outer circumference, and more desirably, if the resin injection line is disposed so as to become two times or more of the resin discharge line, an extremely efficient and high-speed molding becomes possible. ~~Where, symbols~~Symbolds 46a, 47a, 48a 49a in Fig. 9

indicate rubber members for seal, respectively.

Kindly replace paragraph [0101] with the following:

~~Where, although~~Although the number and the position of resin discharge tube 49 are different in accordance with the shape and the dimension of the mold, the number of products to be molded simultaneously in a single mold, etc., the number of resin discharge ports is preferably as few as possible from the viewpoint of stable resin flow and easy operation for controlling the resin flow.

Kindly replace paragraph [0107] with the following:

For this, it is necessary that the already pointed out "resin injection pressure,"[[,]] "molding temperature,"[[,]] "resin flow rate,"[[,]] "thermal property of resin,"[[,]] etc. are set at values corresponding to the molding dimension sufficiently in consideration of the properties of the reactive resin. In particular, ~~in the present invention,~~ because a reactive resin material, which is gelated in a short period of time and quickly cured although it has a good flowability, is employed in consideration of efficiency of production, a high-speed flow and impregnation becomes necessary.

Kindly replace paragraph [0110] with the following:

Example 2

In the RTM molding system 54 according to this embodiment shown in Fig. 11, as an example of molding at molding conditions~~ according to the present invention~~, an example of molding of a large flat plate (length of 1600 mm x width of 700 mm x height (thickness) of 2 mm) will be explained. The whole of the RTM mold 41 used in this example is shown in Figs. 8 and 9, and the relationship between the temperature and the viscosity of the resin used for the molding and the property in resin curing degree-time at the molding temperature are shown in Fig. 12A and Fig. 12B, respectively. On the molding cavity portion 50 provided on the lower die 43 of the mold 41 (length: 2000 mm, width: 1000 mm and height: 350 mm in each of upper die 42 and lower die

43) having resin injection tubes 46 to 48 and discharge tube 49, carbon fiber "TORAYCA" cloth (CO6343B: T300B-3K, weight: 192 g/m^2) is laminated by 8 plies (0/90° oriented substrates: 4 plies, ± 45° oriented substrates: 4 plies), a preform substrate 44 given with a plate shape in advance was disposed, and the upper die 42 was closed by the die lifting device 55 and the mold was completely closed. A pressure of 200 tons was being applied to upper die 42 by the die lifting device 55. Further, the upper die 42 and the lower die 43 are heated almost uniformly and constantly at 100°C by temperature controller 60 (Fig. 12).

Kindly replace paragraphs [0113] through [0115] with the following:

Tubes made of "Teflon" (registered trade mark) each having a diameter of 12 mm and a thickness of 1.5 mm were used as resin injection path 65 and resin injection tubes 46-48 shown in Fig. 11. On the other hand, tubes made of "Teflon" (registered trade mark) each having a diameter of 16 mm and a thickness of 2 mm were used as discharge path 67 and discharge tube 49. ~~In order to~~To prevent the resin from flowing into vacuum pump 58, resin trap 59 was provided on the way of discharge path 67.

Further, ~~in order~~ to seal between resin injection tubes 46-48 or discharge tube 49 and lower die 43, rubber members for seal 46a-49a are disposed, and ~~in order~~ to maintain a tight condition between the upper and lower dies, a mold seal member (O-ring) 45 is disposed, on the outer circumference of the cavity, respectively.

In the above-described molding device, after air in the mold (in the cavity portion) is discharged from resin discharge port 49 by vacuum pump 58 and the pressure in the mold is confirmed to be reduced down to 0.1 MPa or less by a vacuum pressure meter (not shown), the injection of the epoxy resin pressurized by resin injection device 57 having pressurization device 62 is started. ~~Where, the~~The pressurization device 62 uses syringe pumps 62a, 62b, and it is

structure so as to prevent back flow of the resin to the tank side at the time of resin injection. The used resin is a liquid epoxy rein prepared by mixing "Epicoat" 828 (an epoxy resin produced by Yuka Shell Epoxy Corporation) as its main ingredient and TR-C35H (imidazole derivative) of a blend produced by Toray Industries, Inc. as its curing agent. The characteristic of viscosity-time at the mold temperature, that is, at a molding temperature of 100°C, in more detail, the value of cure index, which is used as an index for tracing a curing profile of the resin during viscosity change of epoxy resin composition, is shown in Fig. 12A. From this graph, the resin becomes more than 90% in cure index in a time of about 6 minutes, and reaches a condition capable of being removed from the mold.

Kindly replace paragraphs [0124] through [0125] with the following:

Example 3

Although the above-described Example 2 employed a single plate structure of reinforcing fiber substrate, as another example, when employed was a carbon fiber reinforcing structural material including a foam core (thickness: 10 mm, apparent specific gravity: 0.1) therein (three plies of the above-described carbon fiber "TORAYCA" cloths were stacked on each of the upper and lower surfaces of the foam core), an almost similar molded product excellent in surface quality could be obtained. ~~Where, the~~The time for impregnation was about 4.5 minutes, and was a short period of time similarly to the above-described example.

Next, an RTM molding method according to a third embodiment ~~of the present invention~~ will be explained. First, the production of the fiber reinforced resin molded by this RTM molding method will be explained referring to Fig. 18. As shown in Fig. 18A, a resin injection port 85 and a suction port 86 are provided on an upper die 83 of the double-sided mold. Lower die 84 has a runner for resin injection 88 and a runner for suction 89, and a seal groove 90 is formed around the

cavity. These upper and lower dies 83, 84 are being heated up to a predetermined temperature. After preform substrate 87 as the reinforcing fiber substrate is placed on the cavity surface of lower die 84, upper die 83 is lowered, and the substrate is set in the cavity formed with the upper die and the lower die 84. As the structure of this preform substrate, ~~as defined in the present invention, and~~ as shown in Fig. 13 and Fig. 15, a random mat layer is disposed immediately under the continuous fiber substrate of the surface layer.

Kindly replace paragraphs [0127] through [0128] with the following:

Thereafter, as shown in Fig. 18C, upper die 83 is lifted, and molded product 97 left on lower die 84 is taken out from the mold. ~~Where, the~~The method for producing the fiber reinforced resin ~~according to the present invention~~ can be applied to other methods such as a vacuum molding method, a preprog/autoclave curing method, an RFI (Resin Film Infusion) or a semipreg/oven heat curing method.

By the above-described production method, the fiber reinforced resin ~~according to the present invention~~ was produced as follows.

Kindly replace paragraph [0134] with the following:

In the above-described RTM molding method and device ~~according to the present invention, in order~~ to improve the sealability at the resin injection part and/or the resin discharge part, the following structure can be employed. ~~Where, although~~Although the ~~present invention~~device stands on the basis of assuming the aforementioned divided areas, the following explanation will be taken as to a simple molding model referring to Figs. 20 to 23. This seal structure explained referring to Figs. 20 to 23 can be applied to the RTM molding method and device ~~according to the present invention~~, in particular, to the RTM molding method and device according to the aforementioned first and second embodiments.

Kindly replace paragraph [0138] with the following:

Further, as another structure for improving the sealability is shown in Fig. 21, a reinforcing fiber preform material 123 having a sandwich structure, in which a core material 124 processed in a shape of a product and made of a foamed material covers the outer surface of a reinforcing fiber substrate 125, is placed in a molding cavity 133 formed by an upper die 131 and a lower die 132 disposed with elastic materials for seal 136, 137 communicating with an O-ring (not shown) disposed on the outer circumference of the cavity 133, and a tube for resin injection 134 and a tube for resin discharge 135 communicating a runner for resin injection 138 and a runner for resin discharge 139 are nipped by the upper and lower dies ~~in order~~ to seal them by bringing them into contact with the above-described elastic materials for seal 136,137.

Kindly replace paragraphs [0155] through [0156] with the following:

Further, in the aforementioned RTM molding method and device ~~according to the present invention, in order~~, to enable to discharge small bubbles present in gaps of the substrate, etc., bubbles due to the evaporation of dissolved gas in the resin which are generated by reduction in pressure during resin injection, or fine bubbles staying in the corner portions of the mold, the following structure can be employed. Namely, a structure can be employed for discharging gas in the mold and excessive resin intermittently while injecting the resin into the mold at a pressurized condition, and by this, it becomes possible to cause the resin flow to adequately pulsate and to accelerate the discharge of the bubbles in the resin. In this structure, as to a resin pressure Pm in the mold and a resin discharge pressure Pi at an injection port, the flow rate of the resin flowing into the mold can be controlled by selective control between conditions of Pm=Pi and Pm<Pi, and the resin flow rate also can be controlled by adjustment of a diameter of a discharge port for discharging the resin. Further, a structure also can be employed wherein the adjustment of the

diameter of the discharge port and a timing for the adjustment are stored in memory, and based on the stored information, the resin flow rate is automatically controlled.

In more detail, in a conventional method, a molding method has been employed wherein a reinforcing fiber substrate is disposed in a mold beforehand and the mold is closed, at a condition where an injection valve is closed, the inside of the mold is sucked at a vacuum condition by a vacuum pump through a discharge path communicating with an opened discharge valve, the resin pressure in the mold Pm is reduced preferably at 0.01 MPa or less, and successively, at a condition where the discharge valve is closed, the injection valve is opened and the resin is injected at a pressurized condition until the resin is completely charged into the mold from the resin injection path. In this method, however, because the discharge valve is being closed during resin injection, bubbles left in the weave textures of a woven fabric substrate provided as the reinforcing fiber substrate, bubbles left at a portion between laminated layers of the reinforcing fiber substrate, and further, bubbles generated by evaporation of gas dissolved in the resin injected into the mold in the heat molding process, are not discharged, and by a condition where such bubbles are molded as they are and fine bubbles are left in the molded product, there has been a case causing a great deterioration in quality of the product. In particular, in a case where such bubbles appear on the surface as voids and pits, it has become a defective product for a product requiring a design quality. ~~In order to~~To solve such a deterioration in quality of the product and the problem of occurrence of a defective product, it is necessary to appropriately discharge the gas (bubbles) left in the mold and generated by evaporation even in the resin injection process.

Kindly replace paragraph [0158] with the following:

~~Where, by~~By setting an opening/closing speed of the discharge valve preferably at a speed within one second, the pressure in the mold reduces at a time by the opening/closing speed, and the

residual gas expands rapidly. Then, a resin flow due to the pressure difference and in accordance with a change in volume of the gas is generated, the gas staying between reinforcing fiber substrates or in the corner portions of the mold cannot stay by this rapid resin flow, and the gas is discharged from the discharge port. The higher the reduction speed of the pressure in the mold Pm is, the quicker the change of the gas volume becomes, and by providing the impactive flow to the resin around the gas, residual gas is easily removed from its staying place. The gas once left is discharged integrally with the flow toward the discharge path. Next, the discharge valve is closed, and the resin is supplied from the injection valve.

Kindly replace paragraphs [0164] through [0165] with the following:

Further, in the aforementioned RTM molding method and device~~ according to the present invention, in order~~, to mold a product with a high surface quality efficiently in a short period of time, the following method can be employed. Namely, there are a vertical parting type and a horizontal parting type in RTM molds, and in the vertical parting type (frequently used for injection molding), there is an advantage that occurrence of voids and pits causing a problem on surface quality of molded product is very few because the resin flow is easily made uniform by the influence of gravity and bubbles in the mold are easily released by rising, but there is a big problem that the productivity is low because it is difficult to set a fiber reinforcing substrate in the mold, namely, to dispose the substrate onto the cavity surface of the mold without disturbance and to fix it onto the mold surface and a much time is required therefor. On the other hand, in the horizontal parting type, namely, in the structure where the mold is formed by upper and lower dies, there is an advantage that the setting of the reinforcing fiber substrate onto the mold surface is relatively easy and the setting time is short, but in a general resin injection method, that is, in a case where the resin is pressurized at a pressure of 0.2 to 1.0 MPa and the resin is injected without

particularly controlling the flow rate, the resin flows into the mold at a flow rate depending on the pressure, the resin is charged into the mold in a relatively short period of time, however, there is a case where the reinforcing fiber substrate is disturbed by the resin flow, there occurs an uniform flow with a high flow rate, and many voids and pits are generated on the surface of the molded product. In particular, in a case where the resin is injected at a high discharge pressure of 0.5 MPa or more (therefore, at a high speed) ~~in order~~ to shorten the molding time or mold a product with a large area in a short period of time, a disturbance of the weave structure of the substrate (particularly, a plain weave woven fabric) is liable to occur, and because the resin flows in the mold at a high speed, the flow resistance varies within the flowing region in accordance with a fine unevenness in thickness or difference in structure of the substrate and a uniform flow cannot be maintained, and therefore, there is a case where a large void is generated by occurrence of a local forestalling of the resin flow and the like. Furthermore, there is a case where the resin actually flows up to the substrate portion, but, because the flow rate is high, for example, there is no time for release of gas present in the texture of the woven fabric and the gas stays there, and the gas generates a surface defect as a pit. In such conventional molding condition and molding process causing reduction of quality in appearance concerning the design quality, it is difficult to ensure a high surface quality while carrying out a high-speed injection for shortening the molding time. The larger the size of a product to be molded becomes, the more frequently such a defect on quality in appearance is liable to occur, because a high-speed resin injection is to be inevitably employed.

Because the flow state of resin greatly influences generation of such voids and pits concerning design quality, the density of the reinforcing fiber substrate, that is, the weight thereof, also becomes an important factor. Namely, because a weight of reinforcing fibers per one layer influences a flow resistance of resin and easiness of gas release, it is necessary to set a proper weight in

accordance with the resin flow condition. This proper weight has to be set from the viewpoints of not only the surface quality but also the workability and utilization factor in strength of a preform. Namely, if the weight is too great and the rigidity of the substrate becomes high, the reinforcing fiber substrate becomes hard to be situated along the mold surface and hard to be formed in a three-dimensional shape, and there is a case where it takes much working time to make a preform, or that at that time disturbance of the substrate occurs and the mechanical properties of the FRP molded product decrease. Namely, ~~in order~~ to carry out an efficient production, there is a proper weight corresponding to the production conditions (molding size·shape, molding conditions, etc.).

Kindly replace paragraph [0169] with the following:

Accordingly, in the RTM molding method and device ~~according to the present invention~~, in particular, ~~in order~~ to mold a product with almost no voids and pits and having a high surface design quality efficiently in a short period of time, a method can be employed wherein, when the resin is injected into the cavity of the mold at a pressurized condition, a ratio of a flow rate of the resin per a unit time (Q: cc/min.) to a projected area of the cavity (S: m^2) (Q/S: cc/min.·m^2) is in a range of 50<Q/S<600.

Kindly replace paragraphs [0172] through [0173] with the following:

Industrial Applications ~~of the Invention~~

The RTM molding method and device ~~according to the present invention~~ can be applied to any RTM molding requiring a high-speed molding[[,]] and, in particular, the ~~present invention~~device is useful to mold a relatively large product relatively complicated in shape, efficiently in a short period of time with an excellent surface quality, particularly for molding an excellent design surface.

In more detail, the ~~present invention~~device is suitable for a relatively large FRP panel member for general industries having a product size of 1 m^2 or more, in particular, for an outer panel member or a structural material for vehicles, and among these, it is suitable for RTM molding of an FRP member used as an outer panel member highly requiring a design quality. ~~Where, the~~The outer panel member for vehicles means a so-called panel member such as a door panel or a food in a car or a truck, a roof, a trunk lid, a fender, a spoiler, a side skirt, a front skirt, a mud guard or a door inner panel. In particular, it is suitable for a relatively large panel member requiring a design quality. As other FRP panel members, are raised a member for aircraft, various panels in trains such as a door, a side panel or an interior panel, cover members for construction machines such as a crane, a partition, a door panel or a shield plate in a construction field, and further, an outer surface panel such as a surfboard or a skateboard in a sport field, or parts for bicycles.